NOTES ON SEDIMENTATION IN THE MACKENZIE RIVER BASIN[1]

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INTRODUCTION

In the course of field work in the Mackenzie River region during the summer of 1917 the writer had an opportunity to observe various features in connection with the constructive and destructive work of the rivers and lakes traversed. The following notes relate to the lower Peace, the Slave, Athabasca, and upper Mackenzie rivers, and Great Slave and Athabasca lakes (Fig. 1). The making of these observations was incidental to other work, and they are assembled here as a fragmentary contribution to a knowledge of present-day work in continental sedimentation in the Northwest.

The parallel streams of clear and muddy water in the channel of the Mackenzie, its sloping bowlder-paved banks in marked contrast with the cut banks of the Peace and Slave rivers, and its relatively straight course are among the noteworthy features of this great river. The marked inequality in the rate of sedimentation on opposite sides of Great Slave Lake is one of the significant features in connection with the lacustrine sedimentation of the region. These and other factors relating to sedimentation in the Mackenzie basin will be discussed in the following notes.

MATERIALS OF THE VALLEY FLOORS

The valleys of the Peace and Athabasca rivers are throughout the major part of their courses cut deeply into the shales and sandstones of the Cretaceous formations. At Peace River crossing the Peace River flows in a steep-sided valley cut about nine hundred

[1] Published with the permission of the Director of the Geological Survey of Canada.

feet below the surface of the Cretaceous plateau. The Athabasca, where it joins the Clearwater, has cut its valley into the Cretaceous rocks to a depth of about five hundred feet. The lower portions of both streams, however, flow for considerable distances across a very broad, low, flat plain of recent origin, which is composed

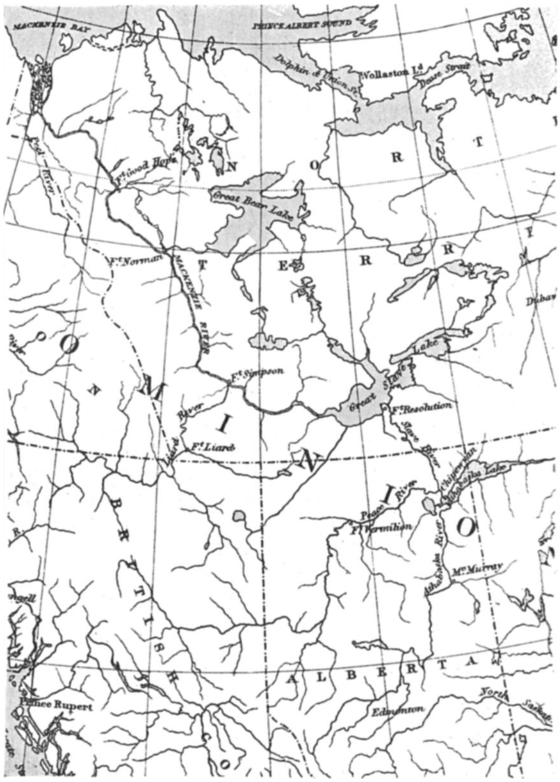

FIG. 1.—Sketch map of the Mackenzie River basin

chiefly of fine silts and sands. These beds are of both lacustrine and fluvial origin and evidently of postglacial age. Near the river the fluvial beds are more in evidence than the lacustrine, but the latter probably have a far greater extent than the former. In the Peace River region the cut banks of sand rising in places 80 feet high or more above the water represent the bottom deposits of a

greater Lake Athabasca which was a contemporary of Lake Agassiz. Similar beds occur along the lower Slave River (Fig. 2), which belong to the period when a much greater Slave Lake was developing the

FIG. 2.—Lacustrine sediments on the Slave River near Salt River, representing deposits of a former greatly extended stage of Great Slave Lake. Photograph by E. J. Whittaker.

wave-cut cliffs and elevated beaches now found far back from its shores. The following section, taken above Little Rapids on the Peace, indicates the general character of these lacustrine beds:

1. Forest bed and soil	1 foot
2. Brown sand	3 feet
3. Forest bed, etc	6 inches to 0
4. Gray sand with pebble band in middle	1 foot
5. Hard sand with limy bands	1 foot
6. White marl	8 inches to 0
7. Gray sand with calcined roots	$2\frac{1}{2}$ feet
8. Marly sand	2 inches
9. Gray even-bedded sand partly covered	30 feet

The broad low plain of lacustrine sands which have been extensively re-worked by the river, extends from the pre-Cambrian hills east of Slave River and the lower Athabasca many miles to the westward. It meets the foot of a plateau called the Caribou Mountains west of the Slave River, while a similar upland known

as the Birch Mountain projects shieldlike from the south into the low land between the Peace and the Athabasca rivers.

The banks of the Mackenzie for the first 200 miles below Great Slave Lake are in some places very low, particularly near the head of the river, though rising 50 to 150 feet above the stream in many places. But the materials in which the channel is cut are nearly everywhere either glacial drift or Devonian shales. It will be pointed out later that the till banks of the Mackenzie give rise to certain peculiarities of the river which are not found in the Slave, lower Peace, and Athabasca rivers, whose channels are cut largely in lacustrine beds.

RELATIVE TURBIDITY

The major part of the great volume of water comprising the upper Mackenzie River is gathered by two large rivers, the Peace and the Athabasca. The latter stream is filtered through Athabasca Lake before joining the Peace. The Peace, united with the Athabasca under the name of the Slave River, pours its flood of sediment-laden water into Great Slave Lake, which discharges it, freed of its burden of floating trees and suspended mud, into the head of the Mackenzie River. The filtered waters of the Slave and half a dozen other considerable streams which flow into Great Slave Lake unite in the upper Mackenzie to form a stream which, in both volume and clarity, is comparable with the upper St. Lawrence. This clear river issuing from the lower end of Great Slave Lake receives no stream of notable size for 150 miles, to the point where it is joined by the Liard from the west. The Liard drains a great area including all the easterly valleys of the Rocky Mountains between the head waters of the Peace and the Yukon. The large volume of the Liard is characterized by a high degree of turbidity. Its muddy waters join the clear waters of the Mackenzie at Fort Simpson, but for more than 160 miles below Simpson they fail to mix except in a limited zone near the middle of the river. During the canoe trip down the Mackenzie observations regarding the relative clarity of the water on the two sides of the river were made repeatedly. The following excerpts from my notes indicate the contrasts observed. Twenty-five miles below the mouth of the Liard River, a crossing from the east to the west bank was made to

observe the relative amounts of sediment on the two sides. On the east side the water was quite clear, the tip of an oar being visible as far down as its length. One third of a mile from the east bank the water showed a trace of sediment, the visibility in looking down into it along the side of an oar being noticeably less. The suspended matter gradually increased toward the west bank for a quarter of a mile. The last third of a mile on the west side held so much sediment that only indistinctly could the bottom of a cup 4 inches deep be seen through it. An oar could not be seen more than 3 or 4 inches below the surface of the water. "At old Fort Wrigley, 140 miles below the Liard, the water on the east side of the river is quite clear, no visible sediment is present, and visibility extends down 3 feet or more. On the west side the bottom of a cup 4 inches deep can be discerned through the water only very indistinctly. The contrast in driftwood also continues striking, being very abundant on the west and scarce on the east side." This contrast, though in a somewhat less marked degree, extended as far as New Fort Wrigley, 160 miles below the Liard, the northern limit of my journey. At Fort Norman a large river brings the clear waters of the Great Bear Lake drainage basin into the east side of the Mackenzie. This large accession of clear water to the east side doubtless results in keeping the eastern half of the Mackenzie comparatively clear to the head of the delta.

Thus we have the curious phenomenon of two rivers, one a clear and one a highly turbid stream, flowing side by side in the same channel without mixing except in a comparatively narrow zone. As a result the deposition of sediment differs markedly in amount and kind on the two sides of the Mackenzie. The islands of alluvial material which occur at various points in the river below the Liard are all confined to the western half of the stream. The abundant supply of drift logs which comes down the Liard furnishes a large amount of drift timber to the west bank of the Mackenzie. Comparatively little of it lands on the east bank.

DESTRUCTIVE AND CONSTRUCTIVE WORK OF THE RIVERS

The Slave River carries vast quantities of sediment into Great Slave Lake. It enters the lake through several narrow channels,

the mouths of the easternmost and westernmost of them being separated by more than ten miles. The lake water in front of the delta is, for some miles out, quite shallow. The submerged margin of the Slave River delta over several square miles is less than a half-foot in depth. This zone is strewn in most places by numberless logs and trees. Inside these comes a broad, irregular fringe of grass-covered land with no willows or other trees, too low for the bank to show. Farther up the delta some of the shores have been built up one foot or a little more above the late summer stage of the water and are covered with willows. Between these islands of the delta, with willow and other low trees, stretches a vast network of shoal-water channels and marsh land. Nearly all these channels are bordered with large quantities of driftwood. Still higher up the delta small poplars are scattered in patches among and behind, or inland from, the willows. Some miles up from the lake, where the banks rise about 3 feet above the water, spruce comes in with poplar. There is, however, no relief beyond the increase of a few inches or eet in the elevation of the shore above water. With this slight elevation cut banks appear, together with the slumping of trees and sections of the bank into the river.

Along the Sawmill branch of the delta willows and alders make a solid wall of low, overhanging brush. The banks under these show great numbers of ogs projecting from the silts, as noted by McConnell.[1]

Above the delta the banks rise to an average height of 7 or 8 feet above the ordinary midsummer stage of the river, and 10 or 15 feet is not unusual. The banks are nearly everywhere of fine silt. The following is a representative section taken several miles above the delta:

Soil and peaty material	1 foot
Silt and dark bands of organic matter in alternating bands	4 feet
Fine gray silt	7 feet

Cut banks are found everywhere on one side or on both sides. These retreat rapidly during the warm season. A trapper's cabin was observed at one point partially undermined by the sapping of

[1] *Canada Geol. Surv., Ann. Rept.*, IV, 1888–89 (1890), p. 66 D.

the river. The spruce timber is found caving into the river along considerable stretches. Where a strong current sets against the bank caving proceeds as rapidly as the face of the cut bank thaws. The heavy mat of moss and vegetable matter prevents thawing downward beyond a couple of feet, or less in most sections. The lateral thawing on the face of cut banks results in overhanging masses of silt covered with forest trees (Fig. 3). These finally break off from the bank as thawing and undercutting proceeds, and the slumping frequently splits the trunks of trees, leaving half of

FIG. 3.—Destructive river work on the outside of a curve, lower Slave River

stump on shore. Islands are formed quickly, and many of them disappear quickly. A sandbar first appears; then a multitude of willows spring up. If ice and floods are not too devastating during the next seasons, the small willows persist and materially aid in adding more sediment to the bar.

The building of silt islands below places of maximum cutting, or opposite cut banks on the inside of the curve which results from their development, is seen throughout the course of the Slave River below Fort Smith. These islands, if near one bank, are likely to have successive zones of sediment added to them on the side next the channel with the lesser current, until it is closed and they become

a part of the mainland. All stages of these islands may be observed, from the sandbar just emerging from the water, with no trace of vegetation, to the island with a mature forest of large spruce. As soon as a bar island is built sufficiently above low-water stages for any vegetation to survive on it, a dense growth of willows covers it. These for some years practically exclude other kinds of trees. Their enormously long roots form a network which protects the loose silty material of the young island from destruction by high water, while their twigs and stems greatly accelerate the accumulation of sediment by checking the velocity of the current around

FIG. 4.—Constructive river work on the inside of a curve. Note three successive growths of willows in front of the tall spruce timber representing periodic increments of silt bands to the river bank.

them. The growth of the silt island is therefore rapid after the first growth of willows has become well established. When the island has been built sufficiently high by the annual accretion of sediment, poplars and later spruce begin to displace the willows. Frequently three or more zones may be distinguished around these islands, each a year or more younger than the one inside it, by the height of the willows on them (Fig. 4).

Above the mouth of Slave River for about 125 miles cut banks of yellow sand 15 to 18 feet high are common for long stretches. They terminate abruptly against the ordinary alluvial banks and evidently represent a different and earlier set of deposits which probably are of lacustrine origin. Immediately below the Grand

Detour cut banks of this yellowish sand and gravel 40 feet high are exposed.

The outermost island at the west end of the Grand Detour illustrates the lateral migration of islands which is sometimes observed. The western border is a recent sandbar formed during the present year. Inside this border is a crescent of willows one year old, while the third zone is a very narrow belt of willows nearly mature. The eastern and oldest part of the island is covered with poplars. This east side, however, is a cut bank and is being removed apparently at the same rate at which the western shore is being built up. On the north half of the Grand Detour the cutting is all on the outside bank, but this is not true of the south half, where islands in the channel deflect the current to the inside of the bow, where it now appears to be doing the maximum amount of cutting in beds of buff sand toward the upper end of the bow.

Near Fort Smith the sandbanks of the river reach their maximum height. At the steamer landing at Fort Smith the top of the bluff is 125 feet above the level of the late-summer stage of the water. The base of the section is a bed of thinly laminated gray clay 6 feet thick with numerous concretions which have the appearance of being built up of a series of disks each smaller than the preceding. Above this laminated clay the beds appear to be composed entirely of sand.

For 16 miles above Fort Smith the Slave River flows over a series of granite ledges and between numerous low, rounded, granite islands which interrupt navigation. Above this series of rapids most of the islands are composed either partially or exclusively of granite or limestone instead of silts as in the lower Slave. Above the Stony Islands, where the granite islands rise to a maximum of more than 100 feet above the river, numerous low, granite bosses also rise at intervals a few feet above the water surface, in many cases only a foot or two above low-water stage. Some of them are only 10 to 20 feet in length. Groups of half a dozen or more of these small granite islands are seen in a distance of 200 yards up and down stream. These granite knobs are the nuclei of the many long alluvial islands seen in this part of the river. Frequently a pile of driftwood caps the top of one of the low granite knobs

(Fig. 5). Such a drift pile checks the current and furnishes the beginning of the conditions essential to island formation. The river makes a deposit of silt below it, and this, in time, may connect with another similarly formed island by downstream growth. These low knobs prevail up to the mouth of the main outlet of the Peace. Above the mouth of the Peace the knobs of granite increase in elevation till 25 feet is an average height. Still higher up the Slave River the granite knobs increase in height toward Little Lake and Lake Athabasca, just north, until an elevation of 150 feet or more is reached. In Peace River the same type of island construction and destruction which characterizes the lower Slave is seen.

FIG. 5.—Island composed of drift timber, Slave River

Great numbers of spruce trees are being undermined constantly and thrown into the river. This timber from the cut banks of the Peace and Slave is the source of the enormous quantities of drift logs which line the shores of Great Slave Lake (Fig. 3). Some of the logs accumulate on the low, granite-island knobs and form islands, some of which appear, at high water, to consist exclusively of logs (Fig. 5). Trees whose roots are heavily loaded with earth and stones often strand in shoal water and form the nuclei of new islands.

The delta of Athabasca River near the western end of Athabasca Lake is very similar to that of Slave River in Great Slave Lake. The lake water in front of it is only 2 to 4 feet deep for a considerable distance except along a narrow, crooked channel. The banks rise above the river (late-summer stage) less than 1 foot for 3 or 4 miles. Higher up from the lake they rise gradually to about 3

feet, when willows become common. Ten miles above the river mouth the banks rise to 5 or 6 feet, and large willows and alders are common, but no spruce trees or other evergreens are seen. The banks of alluvium increase gradually in height till at the old Fort Forks at the head of the delta they rise 10 or 12 feet above low water.

Numerous good examples occur in the lower part of the Athabasca, in the cut banks, of tree stumps which have been buried where they grew under from 2 to 6 feet of alluvium by the shifting of the course of the river. They are illustrated by one of E. T. Seaton's figures.[1] O'Neill[2] has described similar examples of alluvium-buried forest beds in the delta of the Mackenzie where the buried stumps are much larger in girth than any other trees now growing in the delta. The testimony of the land surveyors who have run their lines across an extensive region between the lower Peace and Athabasca rivers indicates that with the exception of two or three localities bedrock outcrops are wanting over a vast area between these two rivers, an area which is doubtless underlain throughout by fluvial and lacustrine deposits.

About 15 miles above the Old Fort forks the river cuts into a sand bluff 75 or 80 feet high. The heavy load of sand acquired by the river at this and other points higher up results in extensive sandbars which are spread over the middle of the river and interfere with steamer navigation at low water. About 3 miles below Point Brule the extensive alluvial and lacustrine deposits are terminated on the east side of the river by land rising 200 feet or more above it.

CONTRASTING FEATURES OF THE MACKENZIE RIVER

The bowlder pavements are among the most striking features of the Mackenzie River. These marvelous pavements, resembling cobblestone roadways, often stretch along both banks of the great river without interruption for miles (Fig. 6). They frequently extend up the concave banks from below low water to a height of 25 feet or more above it. The shores of many of the islands as well as the banks of the river are paved with bowlders. On the Slave, lower Peace, and lower Athabasca rivers the pavements are entirely

[1] *The Arctic Prairies*, p. 197. Charles Scribner's Sons (1911).

[2] *Canada Geol. Surv., Sum. Rept.* (1915), p. 239.

absent. The channels of these streams are cut in lake and river silts which contain no bowlders, while the channel of the upper Mackenzie is cut for the most part in glacial till containing an abundance of bowlders, which through the grinding and sliding of the ice during the spring break-up are pressed deeply into the clay and built into pavements.

The contrast between the bowlder-paved banks of the Mackenzie and the bowlder-free banks of the rivers just mentioned is related to another feature in which the Mackenzie contrasts sharply with these rivers in the bowlder-free silts. The latter meander widely, while the former pursues a fairly direct course, its bends showing none of the characteristics of typical meandering streams.

FIG. 6.—Bowlder pavement on island opposite Old Fort Wrigley, Mackenzie River.

The Grand Detour on the lower Slave is an example of the meanders of this stream and the lower Peace. At the Grand Detour the Slave swings abruptly to the westward in a great loop of about 20 miles. The distance across the base of this meander is only one mile. The relatively direct course of the Mackenzie as compared with the meandering lower Slave and Peace rivers can be explained, in part at least, by the protection which the bowlder pavements afford against lateral cutting. These pavements furnish protection against erosion of the banks as effective as artificial riprap, and thus prevent the excessive cutting at the bends which in many streams leads to the formation of loops and oxbows.

The plowing and gouging action of ice is nearly everywhere in evidence along the Mackenzie. At the head of the river, in the shallow eastern channel, one can see through the clear water numerous deep grooves made by ice cakes or bowlders pushed by ice in the bowlder clay of the bottom. In the gravel or silts of low islands the broad grooves made by ice-shoved bowlders or ice blocks can often be traced for a considerable distance (Fig. 7). In some localities the plowing and scooping action of the ice carries large quantities of mud from the bottom to the banks of the river (Fig. 8).

FIG. 7.—Trail left by ice-shoved bowlder or ice cake. Note the cratic course unlike that left by drifted tree roots, Mackenzie River.

The upstream ends of some of the low islands are built up in this way several feet higher than the rest of the island. In such cases the ice is likely to build a clay dike across the head of the island at right angles to the course of the river terminating at the top in a sharp ridge. The front of such a dike is frequently bowlder-paved and thus becomes almost as resistant to river erosion as a hard rock cliff (Fig. 9).

A feature of the ice work along the banks of the Mackenzie is the distribution of great numbers of a small bivalve, *Sphaerium vermontanum*, over the higher levels of the bank, much higher than the ordinary stages of the river in summer could carry them. I

have never seen this shell in the shallow water of the river, although other shells are common there. It appears, therefore, that it lives

FIG. 8.—River bottom clay and silt shoved on bank of an island by ice scour, Mackenzie River.

abundantly in the deeper parts of the river and reaches the localities where found on the banks as a result of ice excavation and the vagaries of strong current action and transportation during the

FIG. 9.—A clay island protected from erosion by a bowlder pavement

spring break-up. When the ice breaks on the river in the spring, ice jams occur which raise the river to abnormal heights at various localities. McConnell[1] has given the following striking descrip-

[1] *Geol. Surv. of Canada, Ann. Rept.*, IV, 1888–89 (1890), p. 87 D.

tion of this phenomenon as observed by him at the mouth of the Liard:

Huge cakes of ice under the enormous pressure were constantly raising themselves on end and falling, and the whole mass, urged forward by the terrible energy of the piled-up waters behind, was battering a way across the Mackenzie. The ice of the latter, fully five feet thick and firm and solid as in midwinter, was cut through like cardboard, and in a few moments two lanes were formed across its entire width, while a third was open for some distance below, before the force of the rush was exhausted and the movement ceased. In the afternoon the crashing of trees in a channel behind the island, concealed from view by the intervening forest, was distinctly heard and showed that a temporary vent had been found there, and in front of the fort intermittent fountains played at intervals from holes and crevices in the ice. At midnight

FIG. 10.—A remnant of a mass of river-shoved ice and the bowlder pavement which such ice levels and smoothes, Mackenzie River 15 miles above Fort Wrigley.

the dam at the mouth of the Liard gave way and the massive crystal structure was hurled by the liquid energy behind it against the firm ice in front with such force that the whole sheet, for some miles below the fort, was crushed into fragments by the impetuosity of the assault.

At the Ramparts ice jams are reported to have sometimes raised the river nearly 100 feet.

About 15 miles above Fort Wrigley, I observed the remnants of one of these ice jams—an accumulation of great ice blocks which had remained unmelted as late as July 22 (Fig. 10). At this date the principal mass of ice blocks had a thickness of 25 feet. They were covered with a thin veneer of dark mud, and hundreds of specimens of *Sphaerium vermontanum* were scattered over their surface.

Good examples of rock basins which represent apparently one phase of the work done by river ice occur on the limestone island opposite old Fort Wrigley. A considerable area of limestone beds lying approximately horizontal on the northeastern side of the island is covered by the river during the spring break-up, but exposed through the summer. On this area a group of four rock basins has been developed in the limestone. The rim of the largest of these rises from 5 to 10 feet above the bottom. This basin has a maximum length of 65 feet and a width of 30 feet (Fig. 11). Another of these basins has a diameter of 10 feet and a depth of 5

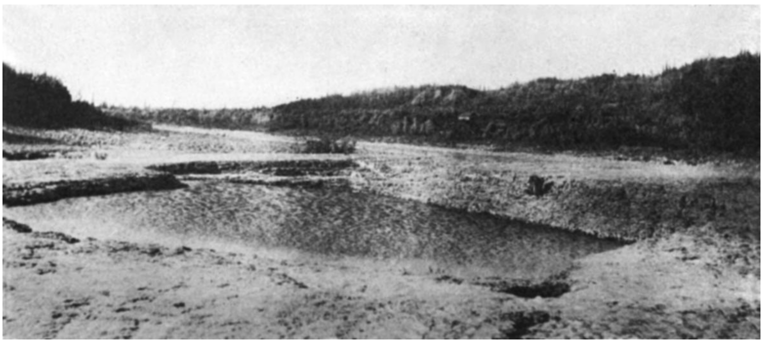

FIG. 11.—A rock basin in limestone between low and high water, Old Fort Wrigley, Mackenzie River.

feet. The basins appear to be the product of the plucking action of the river ice which covers them during the late winter stages of the river.

LAKE FILLING

Two large lakes, Athabasca and Great Slave, lie in the path of the Mackenzie-Athabasca drainage system. Great Slave Lake, much the larger of the two, has a length of about 290 miles from east to west. A recent survey of part of the north shore by A. E. Cameron, of the Canadian Geological Survey, changes the rank in size of Great Slave Lake from fifth to fourth among the great lakes of the continent. As pointed out by McConnell,[1] it seems originally to have had "the form of a great cross with one arm

[1] *Geol. Surv. of Canada, Ann. Rept.*, IV, 1888–89 (1890), p. 65 D.

penetrating the crystalline schists while two others stretched north and south along the junction of these with the newer sedimentaries, and the fourth extended itself over the flat-lying Devonian to the west." Lake Athabasca lies almost entirely within the limits of the pre-Cambrian rocks.

Inspection of the map (Fig. 1) will show that the drainage of an enormous area in Northwestern Canada, extending from the interior of the Rocky Mountains region far into the pre-Cambrian area west of Hudson Bay, passes through Lake Athabasca and Great Slave Lake. Practically all of the vast quantity of sediment which is annually stripped from this extensive area is left in these great settling basins. A noteworthy feature of this lacustrine sedimentation is the extreme inequality of its distribution. Probably 95 per cent of the immense volume of sediment which enters Great Slave Lake is poured into the south side of the lake. The streams entering the north side of the lake are nearly all small and comparatively insignificant. In the course of a survey of the north shore of the west arm of Great Slave Lake, A. E. Cameron found that "throughout the entire 136 miles of shore line between the Mackenzie River and the north arm only one stream, and it a very minor one, was found entering the lake" (manuscript). The streams which do enter the north shore of the lake lose most of their sediment in passing through small lakes before reaching Great Slave Lake. On the south shore, besides the Slave, which is one of the great sediment-bearing streams of the continent, three other rivers enter, each of which has a considerable volume. These are the Taltson, the Buffalo, and the Hay. It is the zone of lake bottom bordering the 150 miles of the south shore receiving these streams which takes the great bulk of the river-borne sediment. Great Slave Lake opposite the mouth of Slave River, which carries the great bulk of the silts entering the lake, has a width of more than 60 miles. Little or none of the sediment brought in by the Slave has any chance of being deposited in the northern half of the lake. Coastwise currents, however, distribute the silts from the Slave and other south-shore streams widely along the south-shore bottom zone. It is probable that along the shore line between the Hay and the Buffalo rivers the prevailing direction of the coastwise

currents is easterly. This was evidently the case off the mouth of the Buffalo when I passed it early in July. The canoe entered muddy water some distance east of the mouth of the stream, but entered clear water immediately west of the west bank of the river, although a breeze from the northeast was blowing at the time. At a later date Mr. Cameron made similar observations at the mouth of the Buffalo. The muddy water of the Slave ceases to be noticeable in the lake 10 or 12 miles west of the western side of the delta.

There is probably no lake in North America which receives anything like the amount of driftwood which is poured into Great Slave Lake, chiefly through the Slave River (Fig. 12). The shores

FIG. 12.—Drift timber on the shore of Great Slave Lake

are nearly everywhere lined with enormous quantities of logs, many of which came from a thousand miles or more up the Peace. Large quantities of this driftwood must eventually become water-logged and sink. Practically none of it leaves the lake by the Mackenzie. At some localities the drift timber is intimately mixed with the shingle of the beaches (Fig. 13).

In Lake Athabasca sedimentation appears to be even more localized than in Great Slave Lake. The maximum length of Lake Athabasca, which nearly equals that of Lake Ontario, lies in an east and west direction. The great bulk of the sediment which the lake receives is poured into the western end by the Athabasca and Peace rivers. It is discharged from this end by way of Little Lake and Slave River. The relationship of the Peace River discharge to Lake Athabasca is peculiar and variable. Three or four

outlet channels of the Peace empty directly into Slave River, but the Quatre Fourches channel, which branches off above the Slave River outlets, empties into Lake Athabasca. Ordinarily by far the greater part of the Peace River water flows directly to Slave Lake via Slave River; but a conjunction of low water in Lake Athabasca and high water in the Peace River may for a time reverse the direction of flow in the upper Slave River and turn all of the Peace River outflow into Lake Athabasca. Such a reversal of drainage involves the temporary obliteration and reversal of Little Rapid, located about 25 miles north of Lake Athabasca in Slave River. Father Lafebre, of the Catholic Mission, informs me

FIG. 13.—A double beach of shingle and drift wood, shore of Great Slave Lake

that he has observed this reversal in May. It thus appears that at times the whole of the combined volume of sediment carried by the Peace and the Athabasca is dumped into Lake Athabasca. When this reversal of current near the head of the Slave River occurs, it is evident that the deposition of sediments must proceed in the western part of Lake Athabasca at an enormously increased rate. Under these special conditions the whole of the Peace River sediment, nearly all of which ordinarily reaches Great Slave Lake, stops in Lake Athabasca. During the unusual seasons when the Peace River contributes largely to the Lake Athabasca sediments, the annual layers of silt would not only be thicker than those ordinarily laid down but would also probably have a much greater easterly extension.

Lakes Mamawa and Clair, lying west of Athabasca Lake, appear to represent parts of a former greater Lake Athabasca which have been segregated into separate lakes by lake filling. Lake Clair has a shore line approximating 200 miles in length. Its depth is reported seldom to exceed 8 feet. Little Lake, through which the outflow of Lake Athabasca passes, is extremely shallow except for a channel through which most of the outflow passes to Slave River. East of this channel a large area on the north side of the lake is completely silted up. On the west side large areas of aquatic plants and stranded logs indicate the approach of the final stage and extinction of the lake.

Observations made on the relative clarity of the Slave River water above and below the mouths of the Peace show but a slight difference in the clarity of the water. This would indicate that the river water passes through the narrow western part of Lake Athabasca too quickly to lose nearly all of its sediment.